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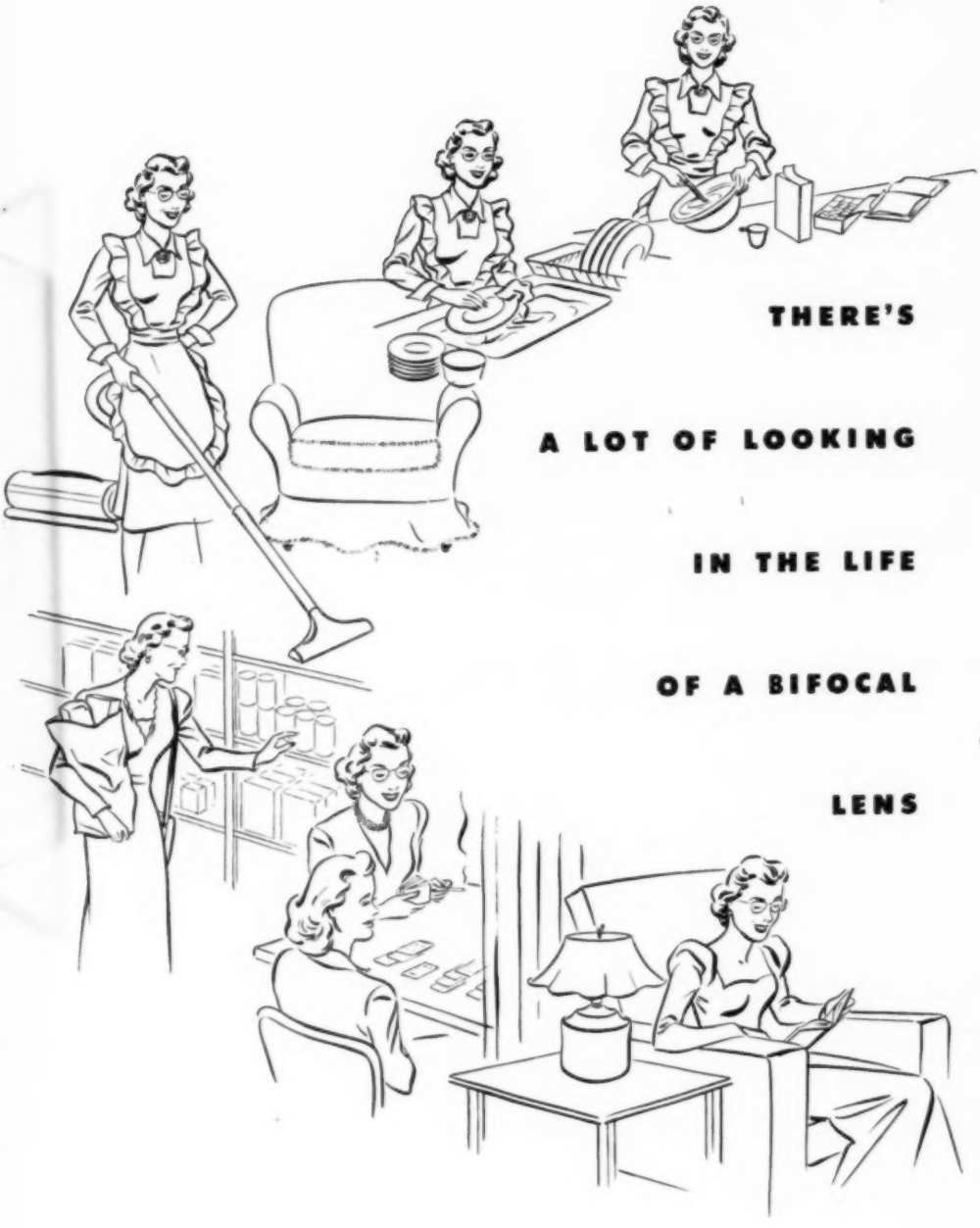

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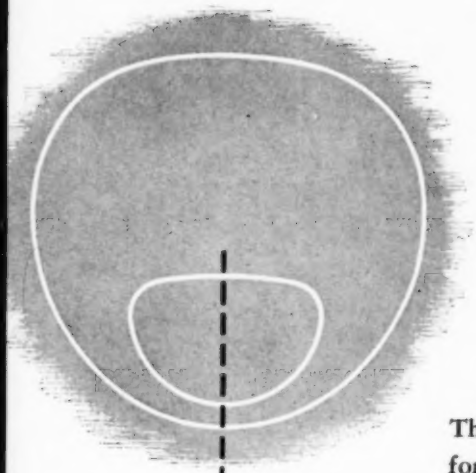

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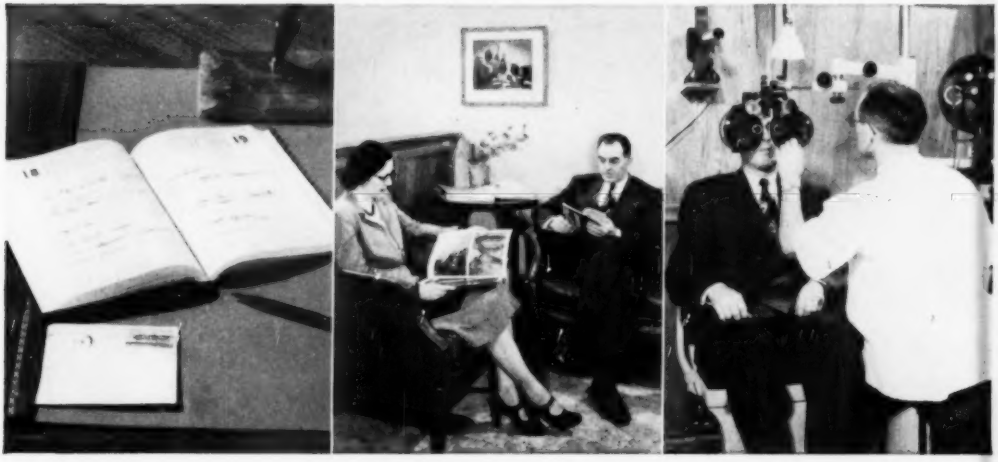

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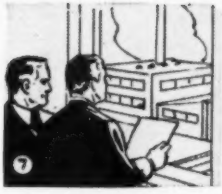

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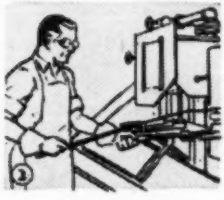

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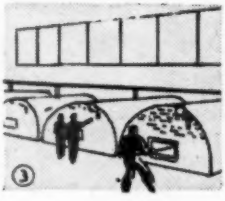

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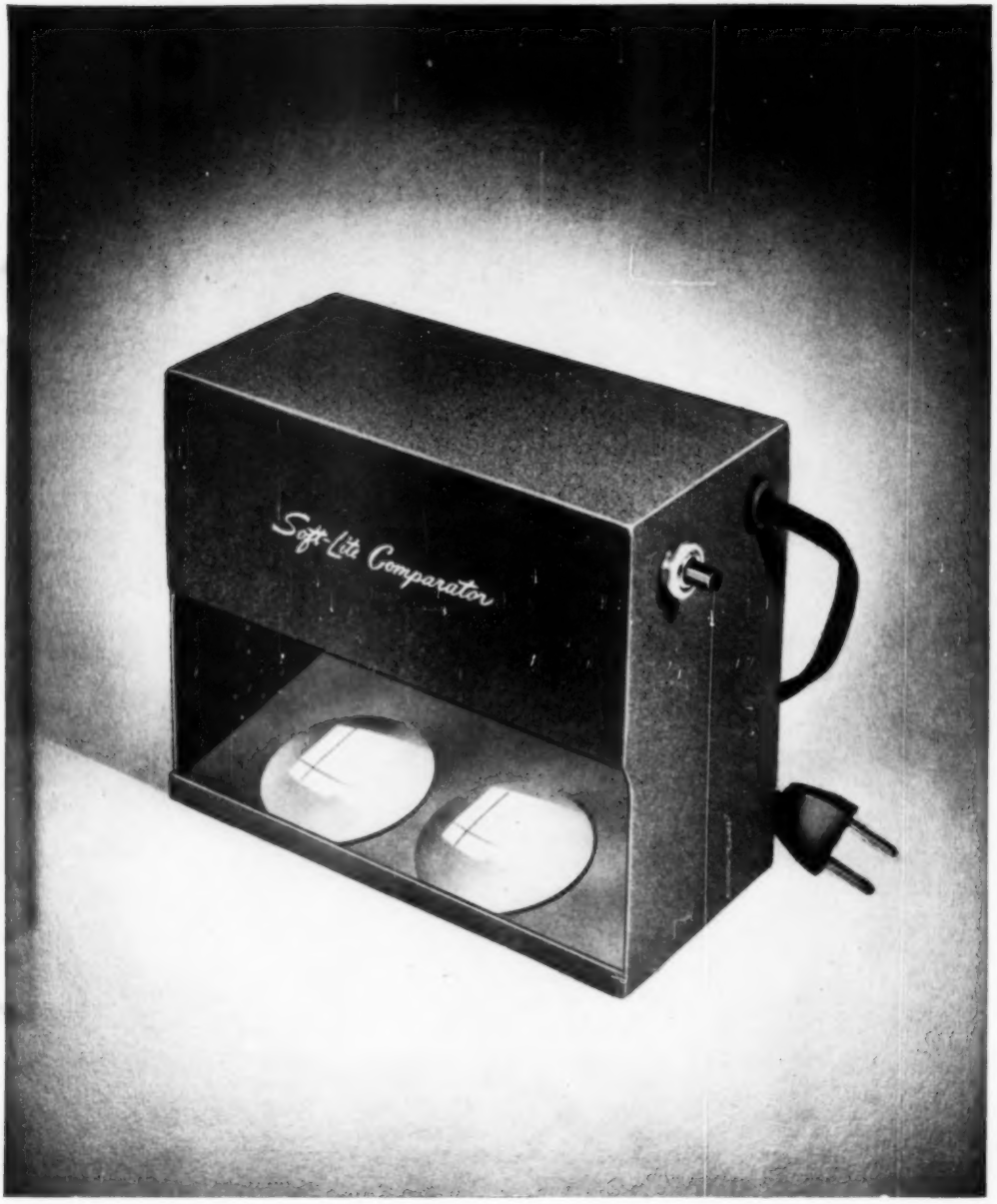

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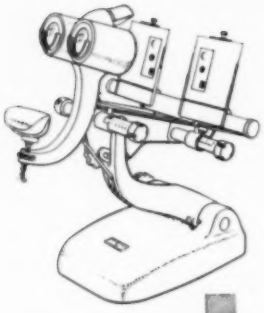

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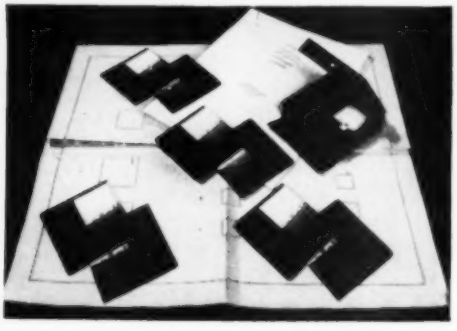

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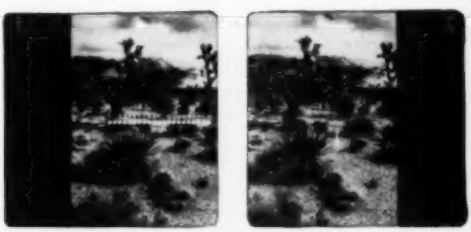

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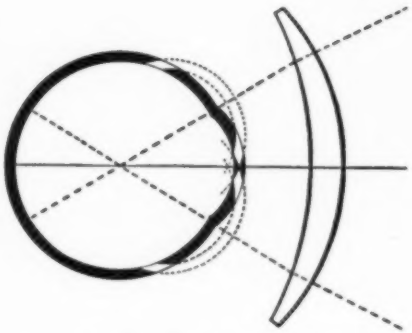

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EXPERIMENTAL INVESTIGATION OF VERTICAL FUSIONAL MOVEMENTS*

Vincent J. Ellerbrock†
School of Optometry, The Ohio State University
Columbus, Ohio

PART I‡

The importance of the fusion reflex in the maintenance of binocular vision necessitates an understanding of the various factors which affect it. Although many characteristics of this reflex are known, its precise nature is obscure. In this investigation, special attention has been paid to the role of the retinal stimuli in the inducement of vertical fusional movements.

APPARATUS

The device which was used to investigate the role of different characteristics of the fusion stimuli in the inducement of vertical fusional movements is schematically shown in Figure 1.

The essential elements of this instrument consist of: two front surface mirrors, two (point of light) sources, and suitable housings for the presentation of fusion targets of different sizes and dimensions to the eyes.

The target housings were mounted so that they could be moved vertically to any desired setting. The positions of the housings were determined by scales graduated in millimeters. The precision of a setting was ± 1 millimeter. The point of light source visible to the right eye was kept at a fixed position. The point for the left eye was adjustable vertically; this was accomplished by mounting the point of light source on a trolley which was movable on an optical bench.

*Read before the annual meeting of the American Academy of Optometry, Winston-Salem, North Carolina, December 5, 1948. For publication in the August, 1949, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.
This investigation was made possible by a grant in aid for research in Physiological Optics by The Univis Lens Company.
†Optometrist. Member of faculty. Fellow, American Academy of Optometry.
‡Part two of this report will appear in the September issue.

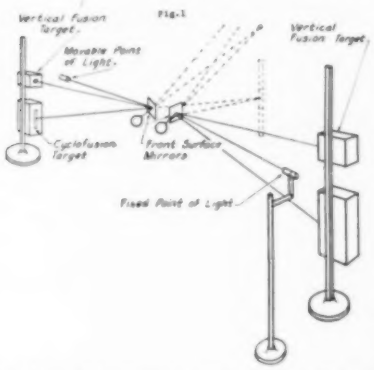


Fig. 1. Schematic drawing of instrument used to investigate the effect of different characteristics of the fusional stimuli on the inducement of positive and negative vertical divergence.

Figure 2. A scale affixed to one rod of the optical bench and a pointer for the scale mounted to the trolley permitted the position of the point of light source to be read with an accuracy of ± 1 millimeter. Provisions were made so that the subject could accurately adjust the position of this source.

In order that the target patterns might be readily changed, the target housings were constructed similar to the one illustrated in Figure 3. The inside surfaces of each housing were painted a flat white.

The vertical planes which contained the targets and point of light sources were 3 meters from the eyes. Although the vertical fusion

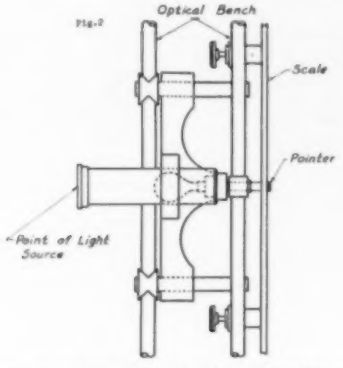
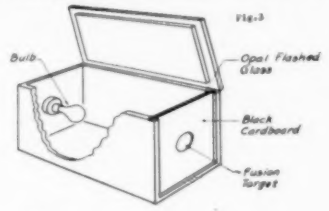


Fig. 2. Detailed sketch of the mounting for the adjustable point of light source.

targets were aligned on the same horizontal axis at their zero positions, the angles of the mirrors necessitated a convergence of the eyes at 3 meters. The background for the targets for both eyes consisted



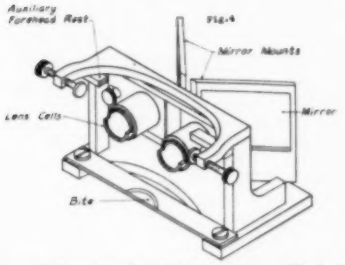


Fig. 3. (Top). Scheme of housing for fusion target. Each housing was made light proof except for the aperture of the fusion target.

Fig. 4 (Bottom). Photograph of the head rest, bite, and lens and mirror mounts which were used in studying the vertical fusion reflex.

of large flat black surfaces on which no details were visible regardless of the brightness of the targets. The stray light from the targets was the only source of illumination in the laboratory during the progress of an experiment. All pieces of apparatus, including the head rest and mirror mounts were painted a flat black to minimize reflection.

The brightness of the vertical fusion targets was 600 c/m^2. This was kept constant in all the experiments with the exception of those discussed in part 2 of this paper, where the role of target brightness on the inducement of fusional movements is discussed. The brightness of the cyclofusional targets was 1800 c/m^2.

The design of the mirror mount, head rest, bite, and cells for holding the lenses before the eyes is evident from Figure 4.

The apparatus employed in this investigation is believed to be superior to that employed by Burian in his investigation of the fusional movements induced by peripheral stimuli. With Burian's apparatus the separations of the fusional stimuli are introduced by mechanical rotation of projection lanterns. The lanterns produced polarized images on a vectograph screen and are viewed through analyzing polaroid

filters. A rotation of the lanterns thus produces a displacement of the fusional stimuli. Unfortunately, there is one great disadvantage in using the technique of polarization. It is well known that when a pair of polaroid filters are set for extinction, there is, nevertheless, an appreciable amount of light which is transmitted[1]. For polarized light reflected from a screen and viewed through an analyzing polaroid the percentage transmission would even be higher. Due to this factor it is practically impossible to isolate the stimuli presented to the two eyes.

EXPERIMENTAL PROCEDURE.

To better understand the technique, one should envision that each eye is fixating identical luminous circular disks which are at a distance of 3 meters from the eyes and subtend an angle of 0.50° at the entrance pupils[2]. And picture, further, that the alignment of the mirrors is such that the eyes have to converge symmetrically on a point at 3 meters for binocular fixation of the disks. Providing that no other stimuli are visible in the visual field, the eyes will assume such directions as are necessary to obtain a single image of the targets. If the disk which is seen by the right eye is now slowly raised or lowered, fusional movements will be induced.

The procedure was followed in this investigation of increasing the vertical separation of the targets in steps of 0.25° with intervals of two minutes between successive increases. The experimental basis for this choice is given later.

It was pointed out in other studies, that the eyes are capable of fusional movements around the lines of sight as well as horizontal and vertical fusional movements. In the absence of stimuli which induce any of these three types of fusional movements, the eyes revert to the fusion-free position for that type of movement. If only stimuli which induce vertical and horizontal fusional movements are present, the eyes will return to the fusion-free position about the lines of sight.

Since lateral measuring points were used in determining the relative vertical positions of the eyes, it was necessary to control the torsional position of the eyes. This control could not be achieved with circular fusion targets and it was necessary to add the cyclofusion targets which consisted of luminous streaks of equal width but of dissimilar length, Figure 5. These targets also controlled the position of

[1]Even for polaroid filters considered to be excellent in quality this may be as high as 0.1%.

[2]The distance of the fusional targets from the eyes for all of the data presented in this report was 3 meters.

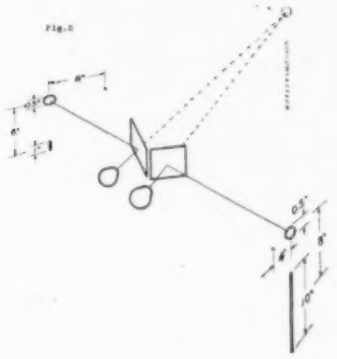


Fig. 5. Illustrative sketch of typical targets employed in the study of vertical divergence. The distance of the targets from the eyes is 3 meters. The dimensions are angular measurements from the center of the entrance pupil. Similar targets inducing vertical fusional movements (in this case the circular targets) are called vertical fusional targets: the retinal images of these targets are referred to as the vertical fusional stimuli. The long and short narrow targets seen by the left and right eye respectively are the cyclofusional targets used to control the torsional position of the eyes. The small, point of light sources are called the measuring points.

the eyes in the horizontal direction. Since the cyclofusion targets did not induce vertical fusional movements, this arrangement permits the circular targets to be the sole determiners of the vertical position of the eyes.

The method which was used for measuring the vertical divergence of the eyes employed two laterally disparate point of light sources (measuring points), one of which was fixed in the primary position of the plane of fixation, and the other which was vertically adjustable. The vertical divergence of the eyes is measured by the horizontal alignment of the adjustable measuring point with the one which is fixed in position.

In the investigation of fusional movements, it is necessary to maintain the fixation of the eyes on a designated stimulus. This is usually difficult for unskilled observers, and as a consequence, only subjects who are capable of sustained fixation for prolonged periods of time were used in the experiments reported at this time.

Although the specific procedures in individual experiments for this investigation varied, the general procedure was as follows: With the head of the subject adjusted in the head rest, the subject fixated a designated stimulus which might consist of the vertical fusional stimuli, a monocular fixation point, or the stimuli used to control the torsional position of the eyes. Regardless of the stimulus fixated, the subject

was required to maintain this fixation except when it was necessary to make a quick glance at the measuring points to aid alignment. With the vertical fusional stimuli set for zero separation the subject adjusted the measuring points so that they appeared to be level. Four settings of the measuring points were made and then the separation of the vertical fusion targets was increased 0.25 degrees. About 20 seconds before the end of a two minute period, the subject again made four settings of the measuring points and the separation was then increased to 0.50 degrees. This procedure was continued until the subject reported that he was no longer able to maintain vertical fusion or until it was obvious to the experimenter by the settings of the measuring points that dissociation had occurred. The experiment was then interrupted for two hours. In the second half of the experiment the same procedure was followed as in the first half but the target was moved in the opposite direction.

SOURCES OF ERROR IN THE MEASUREMENT OF VERTICAL DIVERGENCE.

There are two possible sources of error in measuring the vertical divergence of the eyes by the procedure which has been described, namely, errors due to a torsion of the eyes and errors resulting from small voluntary movements of the eyes in aligning the measuring points. In order to investigate the role of these factors, the amplitudes of vertical divergence for different fusional targets were determined with the two measuring points seen in various positions. First, both points were located so that they were seen on the same side of the fixation target, Figure 5. Then they were placed in such a position that one was seen 4.0 degrees to one side and the second 4.0 degrees to the other side of the fixation target. With the former arrangement, quick small voluntary movements of the eyes were permitted to aid alignment; in the latter, continuous fixation on the fixation target was maintained throughout the experiment.

Figure 6 is an illustration of typical results secured when the vertical fusional stimuli consisted of paired luminous disks 2.6 cm. in diameter. Since the disks were located 3 meters from the eyes, they subtended a visual angle of 0.50°. In Figure 6, the abscissa represents the vertical separation of the targets in degrees; the ordinate stands for the extent of vertical divergence of the eyes. The curves composed of the solid and hollow points depict the vertical divergence measured when the alignment points were on the same and opposite side of the fixation point respectively. The sum of the positive and negative components of vertical divergence is called either the amplitude of vertical divergence or the vertical fusional amplitude.

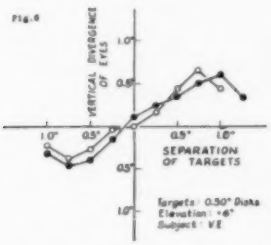


Fig. 6. Results which show that the cyclofusional targets are adequate for the control of the torsional positions of the eyes. The curves formed by the solid and hollow points represent the findings obtained when the two measuring points were on the same and opposite sides of the fixation point, respectively. For these results, the fixed vertical fusional targets was located 6 degrees above the fixation point. This information is given on the graph by the notation—Elevation 6°.

That no essential difference in the results was secured by the different positions of the measuring points is important from several points of view. First, it indicates that the cyclofusional targets employed in the experiments are adequate and do not permit torsional rotations of the eyes. If the torsional position of the eyes had been different in the two experiments, the one curve would have been displaced relative to the second. The finding that the amplitudes of vertical divergence were comparable indicates that rapid, small voluntary movements did not affect the relative divergence of the eyes. However, a generalization of this result for locations of the vertical fusional stimuli other than that used in the experiment cannot be made. The reason for this is that a change of fixation displaces the vertical fusional images from corresponding areas in one portion of the retinas to corresponding areas in another. Since stimuli located in the periphery of the retinas cannot induce fusional movements to the same extent as in the fovea, it is possible that change of fixation might affect the measurement of fusional amplitude when the disparate stimuli are located in or near the fovea.

Experimentally, it was found that when changes of fixations are restricted to momentary glances, taking no longer than several tenths of a second and not being made close to the maximum limit of vertical divergence, they have no effect on the relative divergence of the eyes. These results are applicable to any location of the vertical fusional stimuli.

In keeping with the above findings, momentary changes of fixation in all the experiments in this investigation were made as quickly as possible. Likewise, these changes were avoided near the limit of the fusional amplitude.

There probably is a question concerning the reason why any

changes of fixation had to be made during an experiment. Why not locate the measuring points in order that they are seen on either side of the fixation point and relatively close together? By such a procedure, the images of the measuring points would be incident on the parafoveal region during continuous observation of the fixation point and eye movements would not be necessary to aid alignment. One needs to remember that each measuring point and frequently the fixation point was seen only in monocular vision. Since these points had the appearance of bright star points of light in space it was difficult to prevent their binocular fusion if they were not seen lateral to the fixation point. Accordingly, the positions of the measuring points used in this investigation (Figure 5) were specifically chosen to avoid the problem of binocular fusion of monocular stimuli.

REPEATABILITY OF DATA.

It is a prime requisite in an experimental investigation to know the repeatability of one's data. As a consequence, the procedure was followed by frequently determining the repeatability of results. In the experimental data which will be presented, reference is oftentimes made to the amplitudes of vertical divergence obtained with different fusional stimuli. In most of the experiments which were repeated the amplitudes did not vary more than 10 per cent.

RATE OF SEPARATION OF FUSION TARGETS.

It is known that the rate at which fusion targets are separated affects the amplitude of a fusional movement. Nevertheless, no thorough study of this effect has been made and consequently there is a need for experimental data concerning the role of this factor. The procedure followed in this investigation of changing the separation of the targets only after observing them for a period of time, offers a new approach to this problem.

In Figure 7 are given the representative results secured when the limit of positive and negative vertical divergence were determined by using vertical fusional targets which subtended a visual angle 0.50°.[3] The length of time that the targets were fixated for each given separation of the targets is indicated by the numbers on the curves.

If the amplitudes of vertical divergence are plotted as a function of the length of the interval between successive changes in separations of the targets, the broken curve shown in Figure 8 is secured. Inasmuch

[3]The vertical fusional targets will be henceforth referred to as the targets. In all the experiments in this investigation, the targets consisted of luminous disks of varying dimensions. Because of this, the size of the targets can be expressed in degrees of visual angle. Such a procedure will be adhered to in the remainder of this report.

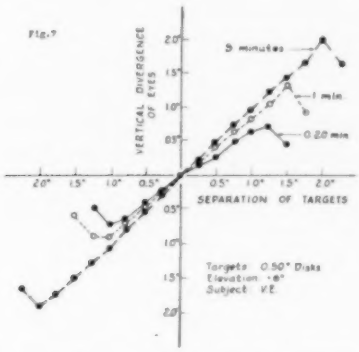


Fig. 7. Representative results illustrating the effect produced by changes in the rate at which the fusional targets were separated. The numbers adjacent to the curves indicate the length of time that the targets were fixated for each 0.25° change in separation.

as the amplitude becomes relatively independent of the length of the interval for ones longer than 2.0 minutes, a 2.0 minute interval was used in all subsequent experiments to be described.

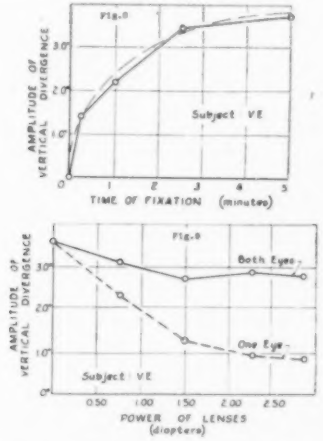


Fig. 8. (Top). The influence of the length of time of fixation between successive increases in the separations of the targets on the amplitude of vertical divergence. Fig. 9. (Bottom). Results of subject V. E. illustrating the amplitudes of vertical divergence which were secured when the retinal images were blurred by the addition of lenses of positive power before the eyes. The curve marked "one eye" indicates that the retinal image of only one eye—the left—was blurred. The data for the second curve were obtained when the images of both eyes were blurred.

SIZE OF THE FUSIONAL STIMULI.

In this section, attention is confined entirely to fusion targets which are no larger than 2.00 degrees and whose images are fixated centrally. For these reasons, the images were located in the foveas.

To investigate the effect of different sizes of targets on the amplitudes of fusion, both fusion targets were varied in size from 0.03 degrees to 2.00 degrees in a series of experiments. For each experiment the fixed fusional target was located at O° elevation. Typical changes of the amplitudes of vertical divergence obtained with targets of different sizes are listed in Table 1.

It is apparent that the relationship between the amplitude and the size of the targets is non-linear. As will be shown later in various ways the uniform surface within the boundary of the targets plays no part in the fusion reflex. The boundary itself, is the important thing. If the targets were squares, the horizontal sides would be more effective than the vertical sides. In the case of the disks, one would expect therefore, that the portion at the top and the bottom would be more effective than the portions to the right and left. But the problem is much more complicated than in the case of squares. Without doubt, the effect of increasing the size of the targets is associated with the length and curvature of the borders.

Angular Size of Target	Amplitude of Vertical Divergence	Relative Size of Target	Relative Size of Amplitude
2.00°	4.25°	1.00	1.00
0.50°	3.60°	0.25	0.85
0.12°	2.51°	0.06	0.60
0.03°	2.03°	0.015	0.47

Table 1. Data illustrating the change of the amplitude of vertical divergence which occurs with the use of different sizes of identical fusional targets. The relative sizes of the diameters and circumferences of the targets are listed in the third column. These should be compared with the relative sizes of the amplitudes in the fourth column. Results are for subject V. E.

An attempt was made to determine whether the size of the pupils would vary for the different sizes of targets. The same targets were presented to the right eye as in the experiments described above but no targets were presented to the left eye. An infrared photographic technique was used to determine the size of pupil for disk targets of various sizes presented to the right eye. The right eye maintained fixation on the target, being photographed. Because no targets were visible to the left

eye, the size of the pupil of the left eye was determined by the consensual pupillary reaction. The results secured are as follows:

Size of Targets	Diameter of Pupil
2.00°	4.07 mm.
0.50°	3.75 mm.
0.12°	3.67 mm.
0.03°	3.88 mm.

Since increasing the size of the disk 67 fold in this supplementary experiment had no significant effect on the size of the pupil, one would also expect that changes in the size of the targets in the fusion experiment would not produce any marked effect on pupil size.

BLURREDNESS OF THE BORDERS.

Heretofore, attention has been directed to the fusional amplitudes secured with stimuli having sharp brightness contrast borders. For theoretical as well as practical reasons it would be of interest to know how blurring the borders would affect the amplitude. One way of effecting such changes is by blurring the retinal image.

When one fixates a point of light, the retinal image of the point is blurred due to chromatic and spherical aberration, and diffraction. The rapid, fine oscillations of the eyes, in effect, constitute another source of blurring. If the eyes are under or over-accommodated for the point of fixation, the blurredness is still further increased. Thus, it is seen, that even in normal circumstances the retinal images are blurred in a number of different ways to varying extents.

The effect of blurring one as well as both fusional stimuli on the limits of positive and negative vertical divergence was investigated by using lenses of positive power before the eyes. The targets consisted of paired luminous disks 0.50° in diameter. The fixed target was located at 0° elevation. In order to avoid small movements of the head during the course of an experiment, bites were employed. Figure 9 shows the results of the experiments in which lenses of various powers were used before one or both eyes. That the blurring of the images of both eyes results only in a relatively small diminution of the amplitudes of vertical divergence is noteworthy.

[PART TWO OF THIS REPORT WILL APPEAR IN THE SEPTEMBER ISSUE]

A REPORT ON THREE CASES OF ANISEIKONIA*

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Holyoke, Massachusetts

This paper deals with three cases showing an apparent aniseikonia, which was corrected, and later on found to have disappeared entirely. In each case the symptoms were quite definite, the findings reliable and the relief was marked. The findings are given in some detail so as to provide a better background for the analysis of these cases. The keratometric readings, phorias, ductions and fundi examinations are not given in the re-examinations as they remained quite constant in each patient.

CASE 1.

The first case is that of a 10 year old boy, the son of a member of the faculty of Smith college.

HISTORY

Severe headaches, particularly if attending movies or doing the ordinary work required in the fourth grade of school. Of his own volition he had given up movies because, in his words, "They give me a headache and stomach ache." His mother also said that he was prone to be nauseated on trains and in automobiles. He was very clumsy and fell down easily. In his first year of school, it was noticed that he learned very slowly, particularly anything that had to be seen, whereas he was quick to grasp anything that could be taught orally. For this reason he was taken to a specialist who pronounced his eyes without any need of a correction and offered the opinion that he would "grow out of it."

No further attention was given until his second year of school even though the symptoms remained undiminished. At this time he was taken to another specialist who stated that there was no difficulty worth correcting but suggested that the boy be given an intelligence test.

This was done at Harvard University and his I. Q. was found to be considerably above normal. Their recommendation was that the boy be given special training on some type of reading-disability apparatus. This training resulted in practically no improvement and the boy suffered more from headaches than formerly.

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†Optometrist, Fellow, American Academy of Optometry.

In March, 1945, the boy was referred to the writer on the advice of a relative who had become familar with the symptoms of aniseikonia.

OPHTHALMOSCOPIC EXAMINATION

Fundi examinations revealed no abnormality. Pupillary action was equal and normal. Versions good. Visual acuity of 20/20-1, O. D. and O. S. (Clason). The patient was left-handed for all tasks and exhibited left-eye dominance by three tests (hole-in-a-card, pointing, cone test).

ANALYTICAL EXAMINATION

Keratometer readings revealed a gross of 1.00 D., W. R., and base curves within 0.12 D.

O. D. 43.00 at 90° 42.00 at 180°
O. S. 42.87 at 75° 41.87 at 165°

Subjective:

O. D. +0.50 D. sph. ⊂ —0.25 D. cyl. axis 180. V. A. 20/20.
O. S. +0.50 D. sph. ⊂ —0.25 D. cyl. axis 165. V. A. 20/20.

Retinoscopy: Agreed fairly well with subjective, if anything, showing about 0.25 D. less plus, but the phoria of 1 Δ exophoria at distance and 1 Δ esophoria at near, indicated the need for full prescription of plus.

Ductions: Abduction 9/5. Adduction 10/4.
Abduction near (16") (Neg. fusional reserve) 24/18.
Adduction near (16") (Pos. fusional reserve) 22/10.

Fusion excellent using F-L card.

Aniseikonia: O. D. 0.50% O. A. ⊂ 1.75% axis 90. Sensitivity ± 0.25%.

Prescription: O. D. +0.50 D. sph. ⊂ —0.25 D. cyl. axis 180. ⊂ 0.50%. O. A. ⊂ 1.75% Ax 90.
O. S. +0.50 D. sph. ⊂ —0.25 D. cyl. axis 165.

Patient experienced very little difficulty in becoming adapted to the correction. In about two weeks his mother reported that the boy was entirely free of headaches and nausea while at school or doing ordinary tasks. He had also expressed the desire to attend movies which gave him very slight headaches but no nausea. From time to time, reports were given that the patient's school work was improving. In less than a year he had caught up with the class in all subjects and had begun to forge ahead of some of his classmates. The improvement continued throughout the year. His parents were pleased to find that the boy wanted to wear his glasses continually.

In October, 1946, the boy came for another examination as the same chain of symptoms had returned but with much less severity than

before. He had been back to school about five weeks and found that he was more comfortable without his glasses. Examination revealed minor change in refraction: viz:

O. D. +0.50 D. sph. ⊂ —0.50 D. cyl. axis 180.
O. S. +0.25 D. sph. ⊂ —0.25 D. cyl. axis 170.

The aniseikonia had, however, diminished to 1.00% axis 90°, O. D. Sensitivity ± 0.25%. This correction was made up and full relief of symptoms obtained.

In July, 1947, the same symptoms returned, with still less severity but yet troublesome enough to cause considerable discomfort.

Refraction showed a slight change:

O. D. +0.50 D. sph. ⊂ —0.50 D. cyl. axis 180.
O. S. +0.50 D. sph. ⊂ —0.50 D. cyl. axis 170.

Aniseikonia had entirely disappeared and sensitivity remained ±.25%. This correction was prescribed and patient is comfortable to date, using his correction only for school or movies.

CASE 2.

The second case was a college professor, age 46. Examination, January, 1943.

HISTORY.

Some nausea, intermittent headache, difficulty in concentrating on reading or other close work. He was using:

O. D. +1.00 D. sph ⊂ —0.50 D. cyl. axis 90.
O. S. +1.25 D. sph. ⊂ —0.75 D. cyl. axis 90.

This had been prescribed two years previously for close work only.

OPHTHALMOSCOPIC EXAMINATION.

Fundi: Normal except for some tortuosity of vessels. Physical examination by his physician revealed blood pressure and urine within normal limits.

ANALYTICAL EXAMINATION.

Keratometer:

O. D. 44.37 at 25 44.00 at 115 (AR).
O. S. 44.62 at 165 44.12 at 75 (AR).

Subjective:

O. D. +0.25 D. sph. ⊂ —1.00 D. cyl. axis 90.
(V. A. 20/20).
O. S. +0.75 D. sph. ⊂ +1.25 D. cyl. axis 90.
(V. A. 20/20).
+1.00 D. sph. Add O. U.

Phorias: Distance, orthophoria. Near (16") with add. 8Δ Exophoria.

Ductions: Abduction 6/2. Adduction. Not taken.
Abduction Near (16") (Neg. fusional reserve) 20/16.
Adduction Near (16") Not taken.

Prescription:

O. D. +0.25 D. sph. ⌢ —1.00 D. cyl. axis 90. / +1.00 D. sph. Add.

O. S. +0.75 D. sph. ⌢ —1.25 D. cyl. axis 90. / +1.00 D. sph. Add.

This was given the patient for constant wear.

In October, 1944, the patient returned, having broken his glasses, and complained that discomfort remained. Slight changes in the correction were found. The patient was advised of the possibility of aniseikonia but preferred not to have an aniseikonic examination at that time.

New formula:

O. D. —1.00 D. cyl. axis 90. / +1.50 D. sph. Add.

O. S. —1.00 D. cyl. axis 90. / +1.50 D. sph. Add.

This correction was worn constantly but the symptoms persisted and the patient presented himself for an aniseikonic examination in June, 1945.

Iseikonic prescription:

O. D. +0.25 D. sph. ⌢ —1.25 D. cyl. axis 90. / +1.50 D. sph. Add.

O. S. +0.25 D. sph. ⌢ —1.25 D. cyl. axis 90. ⌢ .75% axis 90 / +1.50 D. sph. Add. Sensitivity ±0.50%.

The patient reported a great improvement but not full relief. In January, 1948, he returned with complaint that symptoms had recurred more viciously than before. Examination showed the following:

O. D. —0.25 D. sph. ⌢ —1.00 D. cyl. axis 90. / +2.00 D. sph. Add.

O. S. —0.25 D. sph. ⌢ —1.00 D. cyl. axis 90. / +2.00 D. sph. Add.

Aniseikonic examination proved negative with sensitivity of ± .25%. This correction is being worn with nearly full comfort and no recurrence of symptoms to date.

CASE 3.

Mrs. J. R. D. Examination, March, 1943. This patient was my secretary, age 24.

HISTORY.

Headache, radiating to back of neck, attacks of vertigo.
Fundi: Slightly pale, vessels somewhat attenuated.
Uncorrected visual acuity: 20/20 O. D. and O. S.

ANALYTICAL EXAMINATION.

Keratometer:

O. D. 44.87 at 85; 43.75 at 170. (WR).
O. S. 44.75 at 90; 43.37 at 180. (WR).

Subjective:

O. D. —0.25 D. sph. ⊂ —0.25 D. cyl. axis 175.
V. A. 20/20.
O. S. +0.25 D. sph. ⊂ —0.50 D. cyl. axis 180.
V. A. 20/20.

Phorias: Distance, 1Δ Exophoria. Near (16") orthophoria.
Ductions: Abduction 10/7. Adduction 9/8.
Abduction at near (16") (Neg. fusional reserve) 22/10.
Adduction at near (16") (Pos. fusional reserve) 20/8.

Prescription:

O. D. +0.50 D. sph. ⊂ —0.25 D. cyl. axis 175.
V. A. 20/20—.
O. S. +0.50 D. sph. ⊂ —0.50 D. cyl. axis 180.
V. A. 20/20—.

Physical examination revealed that the patient was anemic and she was given liver injections until the blood count was normal.

Late in the Fall, the patient complained of blur at distance, so +0.50 D. sph (OU) was removed from the correction.

In June, 1945, symptoms reappeared except for pain at the back of the neck. No change was found in the refraction so an aniseikonic examination was made:

O. D. 0.75% axis 90.
O. S. 0.50% O. A.
Sensitivity was variable and not too reliable.

Iseikonic prescription:

O. D. Plano ⊂ —0.50 D. cyl. axis 175. ⊂ 0.75% axis 90.
O. S. Plano ⊂ —0.50 D. cyl. axis 180. ⊂ 0.50% O. A.
This provided complete relief.

In October, 1947, re-examination was made as patient had returned complaining of slight headache and inability to read comfortably.

Refraction:

O. D. +0.25 D. sph. ⊂ —0.75 D. cyl. axis 175.
V. A. 20/20.

O. S. +0.50 D. sph. ⊂ —0.50 D. cyl. axis 180.
V. A. 20/20.

The aniseikonic examination showed no disparity of images so a regular prescription was given. The patient has remained comfortable to the present time.

CONCLUSIONS.

Three patients had symptoms relieved by iseikonic lenses. The symptoms reappeared and were alleviated by removal of the iseikonic component of the prescription.

Age did not seem to be a factor, as the range was from 10 to 50 years.

Patients could not properly be termed neurotics, so psychoneurological factors do not account for the changes.

There was very little, if any, basis for the patients having aniseikonia due to anisometropia.

These cases demonstrate the need for continued research in aniseikonia in order to account for changes in the amount and character of aniseikonia, as well as those cases in which the aniseikonia completely disappears.

56 SUFFOLK STREET
HOLYOKE, MASSACHUSETTS.

ABSTRACTS

THE RELATIONSHIP OF REFRACTIVE ERROR TO THE SPEED OF PERCEPTION OF OBJECTS AND WORDS. T. H. Eames. Bulletin of the Massachusetts Society of Optometrists. 29.6.149-151. 1949.

Distinction is made between the perception of form and color and that of words. A group of 100 children (ages 5 to 17 yrs.) was studied to determine the influence of refractive errors upon the perception speed of objects and words.

The correlation of refractive error with:— (1) The speed of object perception, as measured by the author's tachistoscope, was plus 0.54, and with (2) the speed of word perception was plus 0.16. This indicates a moderately significant relationship in the first case but practically none in the second case.

Those cases having ametropia of various degrees were studied further to determine the influence of the refractive correction upon the increment in the speed of object perception correlated with refractive error to the extent of plus 0.46 and the increment in speed of word perception had a correlation of plus 0.50. This shows some correspondence but does not indicate what degree of ametropia is important as a key point beyond which increment is more or less likely to result from correction by means of lenses.

By further analysis of the data, the author concluded that the correction of refractive error of 1 D. or more is likely to result in improved perception speed in an important number of cases.

R. E. B.

REFRACTIVE ERRORS IN IDENTICAL TWINS*

Robert Irving†
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CASE HISTORY.

Patients: Master Steven N., and Master Nicholas N., each, age 16. Unless mentioned otherwise, both patients are considered as one throughout the following report.

Ocular history: The writer's first introduction to the above patients occurred when Master Steven consulted him with a view to having his vision checked. He wished to go to sea and the requirements of the Naval college he was about to enter demanded at least 6/6 vision in one eye with a reasonable error allowed in the other eye.

From a visual point of view he was not eligible, which proved a great disappointment. He was quite agreeable to having his vision corrected with spectacles.

The parents then insisted on Master Nicholas being checked, the same state of affairs existed in his case and the writer was struck with the marked similarity of the two corrections.

PRELIMINARY EXAMINATION.

Lids: Normal.
Superficial cornea: Clear and healthy.
Superficial sclera: Healthy.
Versions: Normal with no restrictions.
Pupillary reaction to light: Direct, normal. Consensual, normal.

OPHTHALMOSCOPIC EXAMINATION.

Cornea: Clear, good luster.
Aqueous: Clear.
Lens: Clear, no opacities.
Vitreous: Clear.

Fundus: General condition good, disk boldly defined, ascending and descending arterio-venous systems slightly different in the two patients, but still having a remarkable similarity.

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ANALYTICAL EXAMINATION.

Visual acuity, uncorrected:
O. D. 6/60. O. S. 6/60. O. U. 6/24.
Retinoscopy: (Master Steven)
O. D. —1.50 D. cyl. axis 145.
O. S. —2.75 D. cyl. axis 15.
Retinoscopy: (Master Nicholas)
O. D. —1.75 D. cyl. axis 140.
O. S. —2.50 D. cyl. axis 15.
Vertical phoria: Orthophoric.
Horizontal phoria: 2 Δ physiological exophoria.
Subjective test at 6 M. (Master Steven)
O. D. —0.50 D. sph. ⊃ —1.50 D. cyl. axis 145. V. A. 6/6.
O. S. —2.75 D. cyl. axis 20. V. A. 6/6.
Subjective test at 6 M. (Master Nicholas)
O. D. —0.50 D. sph. ⊃ —1.50 D. cyl. axis 140. V. A. 6/6.
O. S. —2.50 D. cyl. axis 15. V. A. 6/6.
Phorias and near point convergence. Normal. at 33 cm.

SUMMARY.

There is absolutely no possible indication as to the identity of these boys when they are together and the writer had difficulty in telling them apart. From an amusement point of view the patients did not offer assistance to their identity.

They have exactly the same tastes and dress the same, and they have gone through public school in the same form. The writer was interested enough to have a few words with their dental surgeon who assured him that the dental setup in the twins offered as much confusion as the ophthalmic one.

457 GREAT WESTERN ROAD
GLASGOW, SCOTLAND.

ABSTRACTS

MYOPIA AND CONVERGENT SQUINT. J. I. Pascal. Optometric World. 36 (12). 26 and 53. December 1948.

Myopia is usually associated with exophoria and exotropia, but there are cases where it is associated with esotropia. The five sources of innervation to the convergence are (1) tonic convergence, (2) accommodative convergence, (3) proximate convergence, (4) induced convergence, (5) supplementary fusional convergence. The uncorrected medium and high myope has had to hold everything close to the eyes, and thus built up a strong proximate convergence innervation from the sense of nearness. It is believed that this "nearness" innervation persists in some cases in distance seeing and produces esotropia.

R. E. B.

PUPILLARY CHANGES ASSOCIATED WITH ACCOMMODATION AND CONVERGENCE*

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I. INTRODUCTION.

It has long been argued by various investigators[1, 2, 8, 15, 16, 21] whether accommodation or convergence is the important function in bringing about the constriction of the pupil associated with a change in fixation from a distant point to a near point. The work of Fry[4, 5, 6], Morgan[18], and Hofstetter[10, 11, 12] demonstrating the analysis of convergence into accommodative and fusional components and the close relationship between accommodation and accommodative convergence raises a doubt as to the existence of any basis for these controversies, and suggests that the problem be considered from another viewpoint. In view of this work, the problem now is whether pupil constriction is associated with accommodation and accommodative convergence, or with fusional convergence. The possibility also exists that the constriction may be associated with both these functions.

Fry[7] was the first to approach the problem in terms of accommodation and accommodative convergence and fusional convergence as factors associated with pupil constriction. Unfortunately, his method of measuring the pupil diameter prevented him from obtaining data which could be considered conclusive. The methods of measuring the accommodation and the pupil size were dependent upon subjective judgments which demanded a great deal of skill upon the part of the observer. The results did indicate that the pupil size changed when fusional convergence was brought into play.

In addition to the fact that the method of measuring the pupil diameter required a great deal of skill on the part of the subject, the measures of accommodation and pupil diameter could not be made

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†Graduate Student in Physiological Optics.

simultaneously. Both these objections have been overcome in the present study by using a photographic method of recording the pupil size, and by making continuous measurements of accommodation as the total convergence is changed.

II. APPARATUS.

The haploscope used in this investigation is a modification of the haploscope used by Fry[4, 5, 7] and Hofstetter[10, 11] in their investigations of the accommodative convergence relationship. A plan view of the equipment is shown in Figure 1A. The apparatus can be conveniently divided into three units: a basic haploscope, an accommodation measuring device, and a photographic unit to record pupil diameters. The elements of the haploscope are indicated by corresponding letters, using the superscript to designate the elements of the right arm, and the plain letter for those of the left arm. Since the arms of the haploscope are identical, with two exceptions, one will be described and the exceptions taken up later.

The image of target T′ is viewed by the observer through the optical system consisting of lenses L′ and K′, and the mirror M′. This optical system constitutes a telecentric system for the plane of the observer's pupil, which is located by placing the center of rotation of his

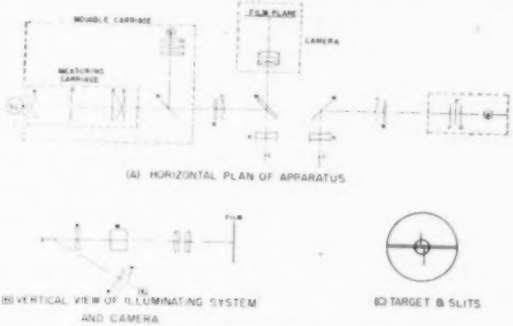

Fig. 1. Apparatus. (C) targets and slits seen by observer.

eye at the point C′. Thus for this system the target will subtend a constant angle for all positions of the target along the arm. Moving the target in this manner changes the stimulus to accommodation. The target is transilluminated by the source S′ and the opal glass disc O′. Neutral density filter F′ is provided to reduce the level of illumination to the desired value.

The arms of the haploscope rotate about vertical axes which pass through the plane of the figure at C and C′. When the observer's head

is placed in the instrument, the centers of rotation of his eyes correspond to these points. This rotation provides a means to change the lines of sight a known amount over a large range of convergence and divergence. The arms are geared together so that the convergence and divergence movements are always symmetrical.

Figure 1C shows the appearance of the target as seen by the observer. The broken vertical slit is used in the accommodation measuring device, and will be described shortly. The targets and the vertical slits provide the only visible light (the infrared illuminating source emits a small amount of visible red) in the room when the experiment is being run. This insures large pupils and a maximum range of pupil change associated with variations in accommodation and convergence. Thus the observer sees in a dark field a disk of blue white light which subtends 5 degrees. Within this disk is a black annulus subtending 1 degree, and two horizontal lines separated by one and one half minutes. The annulus and the outer border of the disk provide a fusion target even at levels of extreme blur. The inter-space between the horizontal lines acts as a criterion to the subject for accurate accommodation.

It was mentioned above that the optical systems of the haploscope arms differed in two respects. The axis of the left arm is bent through 90 degrees by means of the half silvered mirror, N. Whereas M' is a full silvered mirror, M is a plane parallel red filter. The image from the second surface is eliminated by placing a blue filter, B, in the path of the incident light. A similar filter is placed in the right arm in order to render the two images alike in color. The filters used are Corning No. 428, a light blue glass which makes the fields appear bluish white.

The accommodation measuring device consists of elements SL, A, D, E, and G. SL is a sodium vapor lamp mounted in a fixed position at the end of the left arm of the haploscope. A parallel bundle of rays from this source is focused on the vertical slit D placed in the focal plane of condensing lens A. Thus as the measuring carriage is moved along the arm, the illumination of the slit remains relatively constant. Slit D is placed in the focal plane of a bicentric lens, E, which in conjunction with the elements L, M, and K forms a double image of the slit in the plane of the pupil of the observer. The bicentric lens has one plane surface and the other surface is composed of two intersecting spherical surfaces which give the effect of a plus 10.00 diopter spherical lens and a 4.5 prism diopter biprism. G is a short vertical slit whose width governs the width of the slits as seen by the observer. The light passing through this slit enters the eye as two laterally displaced beams, one beam from the upper half of the slit and the other from the lower half. By rotating the bicentric lens with respect to slit D the separation of the

beams can be regulated. The width of the slit images in the plane of the pupil is adjusted by changing the width of slit D. The system was used with the slit images in the pupillary plane 0.2 millimeters wide and their inner edges separated by 2.0 millimeters.

With this system, if the plane of slit G is conjugate to the observer's retina he will see this slit as continuous throughout. If, however, he is accommodated for any other plane, the two halves of the slit will be displaced by an amount proportional to the error of accommodation. Figure 1C shows the appearance of the target as seen when the eye is not focused for the plane of the slit. By using monochromatic light, the effects of chromatic aberration are eliminated, thus providing a very sharp image. It can be seen that the principle of the accommodation measuring device involves a vernier setting of the slit images. This type of an arrangement provides a very accurate measure of the accommodation in play.

A, D, E, and G are mounted on a carriage which can be moved with respect to the larger carriage which carries this assembly and the target assembly along the arm of the haploscope. For a given accommodative stimulus the plane of G will be conjugate with the plane of T if the observer's eye is accurately accommodated for the stimulus. If he is over-accommodating, G will have to be moved closer to N in order for the slits to be aligned. The opposite is true if he is under-accommodating. Attached to the measuring carriage is a stylus which records on a special piece of graph paper the values of accommodation in play for every value of convergence. By means of this recording system, a continuous record is obtained of convergence and accommodation in play for each stimulus to accommodation presented.

The third unit of the apparatus consists of an infrared illuminating source and a modified 35 mm. commercial camera loaded with Kodak Infra Red film. A vertical view of these parts is shown in Figure 1B. The source I is a Mazda 15 candle power bulb (No. 88 special). The light from the filament is concentrated on the pupil by means of lens H after passing through a special Corning heat absorbing filter, P (No. 2600, 2.37 mm. thick). These three elements are mounted in a small air cooled brass housing. An Argus A-2B was modified in such a manner that its objective along with the minus lens K forms a unit magnification system when the subject's eye is placed in the proper position. This was accomplished by placing a scale 10 mm. in front of C, and adjusting the objective until an image, equal in size to the scale, was formed on a ground glass plate in the film plane. The optical units were then fastened securely in place. When a subject was being made ready for a run, his head was moved fore and aft until his pupil was seen in

sharp focus on the ground glass. In this position, the size of the image of the pupil was exactly equal to the size of the subject's entrance pupil and the center of rotation of the eye fell at the center of rotation of the haploscope arm.

The elements described above are all mounted on the haploscope arm, so that they move with the arm in changes of convergence. In this manner the observer's line of sight is at all times coincident with the optical axis of the camera, and the light from the infrared source is always concentrated on the pupil.

An electrical circuit is provided which trips the camera shutter every 2 degrees of total convergence, and automatically winds the film. At the extreme end of the left arm is mounted a micro switch which rides over contacts placed at intervals of 2 degrees on the base of the haploscope. When the switch strikes one of the contacts, the shutter solenoid is energized and the exposure (1/25 sec.) is made. As soon as the shutter closes, a small motor winds the film in preparation for the next exposure.

The observer's head is fixed in position by means of a biting board and head rest. The biting board is provided with 6 degrees of freedom, thus enabling accurate aligning of all subjects. The left eye is first centered subjectively by the use of the images of the slit and target field. Next, this eye is aligned, as described above in the section on the camera, in a fore and aft direction. The right arm is now moved until the proper interpupillary distance is achieved. The arms of the haploscope are next diverged until the images break apart. By observing the doubled image carefully, the observer can now report the presence of any vertical or cyclophoria. If these are present they can be eliminated by rotation of the mirror M′ to raise or lower the right eye image, and by a rotation of target T′.

III. PROCEDURE.

As was pointed out in the last section, the experiment was carried out in a dark room, thus insuring a large pupil and minimum effects due to the integration of the pupil response being studied and the light reflex. The light reflex tends to diminish the constriction associated with accommodation and convergence, since as the pupil constricts in response to these factors, a negating effect is established by the light reflex in an attempt to maintain the retinal illumination constant. The brightness of the targets was 0.42 millilamberts as viewed through the optical system. The operator adjusted the equipment using a flashlight which had been covered by a red filter to insure dark adaptation on the part of the observer. The observer's face was shielded to prevent

the light from the targets which did not enter the optical system from striking the face.

Each subject was run as follows. After a preliminary training period (outlined below) a wax biting board was made for the subject and his head placed in the haploscope and properly aligned as described in the section on apparatus. Next, the room was darkened and the subject was put through two dry runs. Each dry run consisted of a phoria measurement, a divergence from the phoria position to the base in break point, and a convergence from the phoria position to the base out break point. While the arms of the haploscope were being diverged and converged the subject adjusted the position of the small carriage on the left arm in order to keep the vertical yellow slits aligned. This produced a record on the graph of the accommodative response during every moment of the run. One dry run was made with the accommodative stimulus fixed at zero diopters, the second was made at a fixed stimulus of 6 diopters. In several cases where the amplitude of accommodation indicated that higher values of accommodation could be maintained, the second dry run was performed at a fixed stimulus of 9 diopters. The only datum recorded in the dry run was the phoria position.

The phoria was measured in the following manner. The target on the left arm was blocked off so that the left eye saw only the vertical yellow slits, the right eye saw the circular target. The subject was now instructed to maintain the right eye target clear (that is, maintain resolution of the horizontal lines) and to align the yellow slits and to center the slits in the annulus seen by the right eye. When the subject indicated that he had completed the setting, the phoria position was further checked by flashing the yellow slits. A black occluder was introduced into the path of the light rays from the slit. It was held in the path for about 2 seconds and then removed for about 1 second. This procedure was continued until the slits remained centered in the 1 degree annulus. It was not alway possible to maintain the slits in the center of the annulus, but as long as they remained within the circle, the phoria position could be considered stable to within plus or minus one-half degree. All the observers reported that the image moved within the circle, but never that it fell outside the circle at the final setting of the phoria reading.

The dry runs were performed under conditions of the final runs, that is, all the lights in the room were turned off and the shutter circuit and infrared illuminating lamp were turned on. Thus the observer performed during the dry runs while being subjected to the conditions of the final runs. When the dry runs were completed, the subject was

given a short rest while the film was being loaded into the camera. In the final runs, the accommodation stimuli were set at 0, 2, 4, and 6 diopters (for those subjects who had greater amplitudes, the stimuli were set at 0, 3, 6, and 9 diopters).

During each run the subject was instructed to keep the fused targets clear as long as possible and once they blurred to keep them fused as long as possible. When the targets broke apart, the subject was asked not to try to refuse them, but instead to inform the operator that the images had broken. When the targets broke or the accommodation measuring carriage reached its limit, that portion of the run was completed.

Each subject used in the experiment was given at least one preliminary sitting before the above procedure. The minimum training and practice given to each subject is given here. On a day preceding the day of the final runs, the purpose of the experiment and the apparatus were explained to the subject. His head was placed in a chin rest in the haploscope and the eyes aligned as outlined above. He was then instructed in the manner in which to make a phoria setting. Finally, he was put through three dry runs, one at a fixed stimulus of zero diopters, another at a fixed stimulus to accommodation just below his maximum accommodation level, and a third at an intermediate level of accommodation.

Subject MJA was not run in the above manner since his high ACA ratio prevented complete plotting of the zone of single binocular vision. The limit set by the construction of the haploscope made this impossible. He was trained as were the others, but instead of making a complete run the pupil was photographed along the phoria line only. In the case of MJA, the points plotted in the pupil curve represent an average of five determinations each.

The subjects used were members of the staff of the School of Optometry, and juniors and seniors in the School of Optometry. The subjects were permitted to wear their distance correction if they normally wore one. Photographing the pupil through the corrections introduced a small change in magnification, but since the relative change in pupil size is the important factor, this does not detract from the validity of the data.

IV. RESULTS.

The raw data for one of the subjects are shown plotted in the top graph of Figure 2. The numbers at the right of each curve indicate the accommodative stimulus used. It can be seen that it would be difficult to analyze the pupillary changes in terms of accommodation and accommodative convergence and fusional convergence from this sort of a plot.

In order to facilitate this analysis, the data have been re-plotted as shown in the lower graph of Figure 2. Here, the relationship between pupil size and accommodative response are plotted for various amounts of

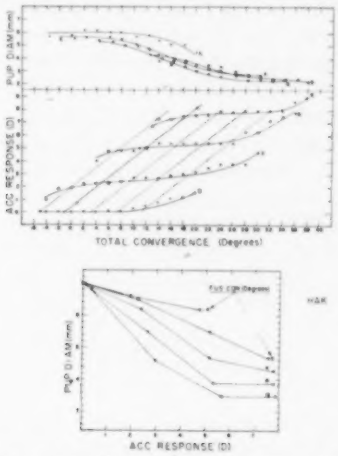

Fig. 2. Upper graph—Raw data of accommodative response and pupil diameter plotted against total convergence. Iso-fusional lines are shown for every 4 degrees of fusion l convergence. Figures at the right of each curve indicate the accommodative stimulus presented in each case.
Lower graph—Pupil diameter vs. accommodative response.
Data extracted from upper graph. Figures at the right of each curve indicate fusional convergence in play.

fusional convergence in play. The figures to the right of each curve refer to the amount of fusional convergence in play.

The method of extracting the data for this curve is illustrated in the upper graph of Figure 2. Lines have been constructed parallel to the phoria line at equal horizontal distances across the graph. These lines represent values of constant fusional convergence, and will be referred to as iso-fusional lines. The four values of accommodative response and pupil diameter for a given level of fusional convergence can now be read directly from the graph. The value of accommodative response is simply the ordinate of the point of intersection of the iso-fusional line and the accommodative response curve. The abscissa of the point of intersection is next extended to intersect the corresponding pupil curve above in order to obtain the value of the pupil diameter at the given values of fusional convergence and accommodative response. The data for all the observers plotted in this manner are shown in Figure 3. (The figure below each subject's initials indicates his ACA ratio). The data shown in Figure 3 for HAK were obtained on a separate day from those

shown in Figure 2. The two sets of data are shown to indicate the repeatability of the data. Since the pupil diameters for MJA were measured only along the phoria line, the data in Figure 3 represent the values of pupil diameter for zero fusional convergence.

The data which showed significant changes in pupil diameter with changes in fusional convergence have been plotted in the top four graphs (subjects HAK, BCB, NG, and SS). The remaining six cases do not demonstrate a significant constriction associated with changes in fusional convergence. It will be noted that it was not possible to obtain large variations in fusional convergence in these subjects.

An inspection of the data of the four subjects which show a change in pupil diameter with a change in fusional convergence brings out a second point, namely, that the effect of fusional convergence upon pupil

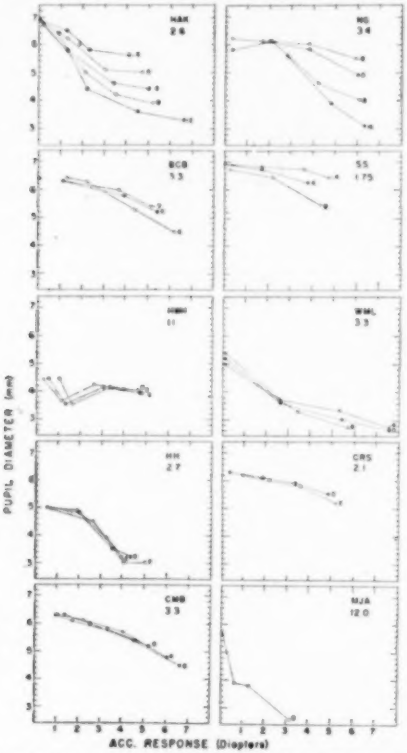

Fig. 3. Data for all subjects plotted as in lower graph of Figure 2. The figure below subject's initials indicates ACA ratio.

constriction is greater at the higher levels of accommodative response than at the lower levels. This is evident from the increase in the separation of the curves at the higher levels of accommodative response. It follows from this, that the pupil change associated with accommodation and accommodative convergence also increases as the fusional convergence is increased. This is represented by an increase in the slope of the curves as the fusion level is increased.

In an attempt to analyze the pupillary changes in terms of accommodation and accommodative convergence, the following data were extracted from the graphs. The curves labeled zero represent the pupillary changes associated with accommodation and accommodative convergence when there is no fusional convergence in play. This relationship can be seen to be roughly linear and the change in pupil size for a given change of accommodation (Δ Pupil Diam. / Δ Acc.) can be expressed as the mean slope of the various segments. This will be referred to as the PA ratio. Plotting the PA ratio against the ACA ratio shows whether the pupil constriction is more closely associated with accommodation or with accommodative convergence. If the pupil constriction is related only to accommodation, this plot should show a random distribution. If, on the other hand, accommodative convergence is the more important factor, the PA ratio should show some correlation with the ACA ratio.

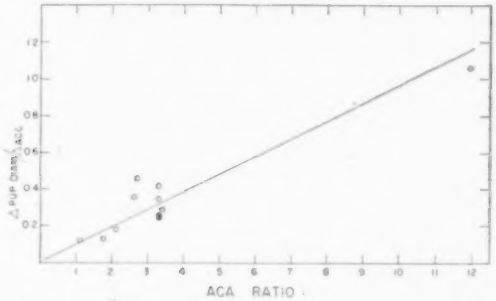

Fig. 4. Scatter plot showing relationship between PA ratio (change in pupil diameter per diopter change of accommodation) and ACA ratio.

The data have been plotted in Figure 4, and it is seen that the distribution of the points indicates that the rate of change of pupil size correlates roughly with the ACA ratio in a positive direction. One might infer from this finding that the pupil constriction associated with accommodation and accommodative convergence is more closely associated with accommodative convergence than accommodation. This is, however, not a final conclusion since the number of cases and the skewed

distribution would not allow any definite conclusion to be drawn at this time.

V. SUMMARY.

The results of this study may be summarized as follows:

1. Pupillary constrictions were found to be associated with increases in accommodation and accommodative convergence in all 10 subjects investigated.

2. A pupil constriction is associated with increases in fusional convergence in at least some individuals.

3. When fusional convergence is zero, the relationship between pupil diameter and accommodation is roughly linear. The ratio of pupil change to accommodative change can be conveniently referred to as the PA ratio.

4. The PA ratio in different individuals varies over a large range. The extremes in the 10 subjects measured were 0.1 and 1.1 millimeters per diopter of accommodation.

5. The PA ratios determined show a fair correlation with the ACA ratio. If this correlation may be considered to be significant, it points to the conclusion that pupil constriction is more closely associated with accommodative convergence than with accommodation.

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BOOK REVIEW

THE ARNESON KORECTOR. T. J. Arneson. Published by the Korector Sales Company. Nicollet Arcade Bldg., Minneapolis, Minn. 129 pages. Illustrated. Cloth. $5. 1949.

This is a manual to be used with the Arneson Korector, an orthoptic device consisting of a motor driven fixation disk mounted upon a movable stand. The disk is 20 inches in diameter which can be made to revolve smoothly in either direction at speeds variable from 12 to 45 r. p. m. The disk may be illuminated by means of a tubular silvered bulb encased in a housing above the disk. The disk which has a pattern of black, blue and red on a background of ivory contains a target light to enhance fixation. The instrument is designed to be used at any distance from 20 feet to 20 inches.

The text of the manual consists of a section devoted to a description of the instrument and its uses in cases of binocular anomalies, amblyopia, asthenopia, etc. Other sections are headed: (1) Diagnosis, (2) Discussion, (3) Treatment, (4) General, (5) Case Histories.

The techniques used with the Arneson Korector were developed by the author in Minneapolis over a period of 25 years. The method is referred to as the "Myo-Fusion Technic." The term, "Myo-Fusion," refers to two elements of binocular vision: ocular muscles and fusion. The Myo-Fusion Technic is applicable primarily to non-pathological cases which fail to receive comfortable and efficient binocular vision despite proper ametropic correction.

The case histories are interesting and presented in a comprehensive manner. The symptoms, diagnosis, treatment, before-after findings are given together with the subsequent reports relative to symptoms.

ROBERT E. BANNON

PLASTIC LENSES MADE OF THERMOSETTING RESINS*

Robert Graham†
Los Angeles College of Optometry
Los Angeles, California

In recent years plastics have been produced with properties so exceptional as to make them the most promising new optical media since the invention of glass. They weigh half as much as optical glass: are highly fog-resistant and practically unbreakable.

Such materials quite evidently create the possibility of lenses superior to those of glass in several respects. For this reason mastery of them for lens making purposes has been undertaken by some of the finest research minds in the country. The United States Government financed plastic lens projects at Polaroid Corporation[1], at Harvard University and at the California Institute of Technology[2]. Eastman Kodak, American Optical, Bausch and Lomb, Univis, Goodrich and other companies inaugurated plastic lens research projects. So worthwhile was the goal that one company expended over a quarter of a million dollars on a plastic lens project.

That this array of technical ability did not develop plastic ophthalmic lenses is not entirely surprising. The problems inherent in plastics are formidable. Because of their great resilience and high coefficient of thermal expansion the methods of grinding and polishing applicable to glass become prohibitively slow when applied to plastic lenses of ophthalmic dimensions[3].

Plastics do lend themselves to die-forming. When the proper conditions are maintained, it is possible by such forming to consistently produce surfaces of superior ophthalmic quality. Since the polystyrenes are the most tractable of the optical plastics they were the first to be formed into good lenses. They proved too soft for ophthalmic use. The next materials tried were the acrylics of commerce[4]. Lenses of these were introduced in 1937. Although they found a number of users,

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†Optometrist. Member of faculty. Director of research, The Armorlite Lens Company. Fellow, American Academy of Optometry.

[1]National Defense Research Committee contract OEMsr-70, 1940.

[2]National Defense Research Committee contract OEMsr-657, 1940.

[3]It is probable that polishing results in an abnormal condition of stretched and deformed surface molecules. This tends to right itself by a return to the original surface conformity.

[4]Lucite; Plexiglas.

they were still rather soft and were withdrawn from the market in 1939. For the next eight years plastic spectacle corrections were not available to the eye professions.

In 1947, the research staff of the Armorlite Lens Company undertook to develop a process permitting utilization of the hard thermoplastics. Their subsequent invention of the minimum flow process enabled them to employ the hardest available types of thermoplastic resins[5]. These are free of plasticizer—hence appreciably harder and more heat-resistant than materials previously used for lenses. As a result, the writer believes, this company became the first in America to make practical plastic lenses available to the eye professions[6]. Since the introduction of these lenses, late in 1947, thousands of pairs have gone into use throughout the country.

These were, however, relatively limited applications. The limitation arose almost entirely from the vulnerability of the lenses to abrasion. Other types of transparent materials offered the possibility of overcoming this. Certain of the thermosetting resins possess a hardness many times that of the hardest available thermoplastic resins[7].

With these the problems of lens fabrication arise from the fact that the material, once hardened by heat, cannot again be softened or re-formed. Furthermore, during its one solidification its volume diminishes as much as 14 per cent. Flat sheets and plano goggles may readily be formed from the liquid monomer. But where the surfaces are not parallel, as in powered lenses, severe problems are introduced.

Much ingenuity has been expended in efforts to overcome these problems. When the lenses shrank from the dies, one company undertook to fill these spaces with additional fluid monomer prior to a second curing. Another company mixed plastic granules with the liquid monomer so that most of the mass would have undergone shrinkage before its placement between dies. These approaches introduced their own problems of optical non-homogeneity and easier splitting of the material. Lenses so made did not appear on the market.

The research staff also addressed itself to the problem of developing optical uses of the hard, transparent thermosetting resins. It is gratifying to report that within the past year this staff has invented a

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[5]U. S. patent applied for.

[6]Graham—American Journal of Optometry and Archives of the American Academy of Optometry, October, 1947, v. 24, no. 10, pp. 1-4.
Graham—Quarterly Review of Ophthalmology, June, 1948, v. 4, no. 2, pp. 141-2.

[7]The structure of the thermosetting plastics, in which chemical bonds are established between the molecular chains, approaches the three-dimensional network of diamond. Such a cross-linked structure results in far greater hardness than that of the linear-linked thermoplastics.

process[8] so controllable that perfectly homogeneous lenses of excellent quality are now being produced from the hardest known optical plastic in its hardest known form. Such lenses are 36 times as hard as their predecessors. This results in highly satisfactory resistance to abrasion. They may be cleaned repeatedly on any common fabric without harm.

These are not once-in-a-lifetime lenses. It is estimated that, under normal conditions, they will give excellent performance until time for the average prescription to be verified or changed.

Such lenses are superior to crown glass in resistance to any of the common chemicals. Because of their resilience and low thermal conductivity, they are at least 10 times as resistant as glass to welding spatter and sparks from grinding wheels. In identical thicknesses they equal or surpass the best case-hardened glass under the standard drop-ball test. When 1/8 inch steel pellets are shot against the material the minimum break point is five times that of case-hardened glass.

Comparative Table of Constants

	Glass	Methacrylate	Thermosetting Resin
Specific gravity	2.5	1.2	1.25
Refractive index (nD)	1.52	1.49	1.5
Resistance to fogging (X glass)	1.	5.00	4.5
Light transmission (%)	88.	90-92	90-92

SUMMARY:

The lightest of all types of lenses and one of the safest to wear have now had their serious limitation reduced to negligible proportions. Featherweight ophthalmic lenses with outstanding qualities of resistance to abrasion, condensation, chemicals, and physical impact have become available to the eye professions.

[8]To be described in a subsequent report.

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CHARLES SHEARD

One of the most familiar figures—and one of optometry's most devoted friends—will be missing from the staff of the Mayo Clinic this Fall. Dr. Charles Sheard will officially retire at the end of this Summer from the positions of director emeritus of the division of physics and biophysical research of the Mayo Clinic, and professor of experimental biophysics, the Mayo Foundation, Graduate School of the University of Minnesota. The rules of the University of Minnesota and the Mayo Clinic so deem it, Dr. Sheard having reached the age of 65.

But retirement will not mean inactivity for the slender, white-haired man who has ceaselessly worked for the interests of optometrists, health workers, and other scientists, as well as mankind, for more than 42 years. During the winter months of the coming collegiate year, Dr. Sheard will both teach and direct research in ophthalmology

at Tulane University in New Orleans, Louisiana. The remainder of the year, he will reside in Rochester, Minnesota, and continue his supervision of the opticians' course at the Rochester Junior College. He plans to continue a similar schedule indefinitely.

Fortunately for optometry, Dr. Sheard has decided to continue working in the field of visual science. Although internationally famous in several fields of scientific endeavor, visual research has always been, according to Dr. Sheard, his chief interest—"whether or not it was always apparent because of other researches, duties, and responsibilities in the broader realm of biophysics."

Dr. Sheard need not worry that his interest in visual science has been obscured by his many accomplishments in other fields. His devotion to the problems of vision is known by optometrists the world over—through his efforts toward the establishment of the university-affiliated school of optometry at Ohio State University in 1914; through his work in the Scientific Bureau of the American Optical Company from 1919 to 1924, and as editor of the AMERICAN JOURNAL OF PHYSIOLOGICAL OPTICS; through his teaching and research activities at the Mayo Clinic since 1924, and more recently by his work with the Rochester Junior College Opticians' Course and the Sheard Foundation for visual research at Ohio State. His work with dynamic skiametry and the accommodation-convergence relationships will live forever in our scientific records as proof of his deep interest in visual science.

Educational institutions and scientific groups both here and abroad have honored Dr. Sheard with honorary degrees, certificates of merit, scrolls and editorial bouquets. Fellowships have been awarded him in the American Physical Society and the Ophthalmic Institute of Great Britain, the Optical Society of Great Britain, the American Society of Plant Physiologists, the American Physiological Society, the American Society of Chemical Pathologists, the American Association for the Advancement of Science, Sigma Xi, the Society for Experimental Biology and Medicine, and our own American Academy of Optometry—to name only a few. Recently, his associates at the Mayo Clinic presented him with a $1,000.00 United States bond for the Sheard Foundation and the University of Minnesota honored him with a citation for his contributions to the welfare of the University and the State of Minnesota.

But it would be difficult indeed to find a material award which would show optometry's gratitude for this great scientist's contribution to the profession. It can only be hoped that he knows the profession recognizes the debt it owes him for the major part he has played, and

continues to play, in bringing optometry to its proper professional status and helping to solve the problems of visual science.

Now, as Dr. Sheard passes another milestone in an incomparable educational and scientific career, optometry joins others in wishing him the thing he most desires—"many long years in the service of men and all things scientifically and professionally concerned with human vision."

VIRGINIA HUCK.

SPECIAL REPORT

SOCIALIZED MEDICINE*

AN ANSWER TO "A PLEA FOR A PROGRAM OF PREPAID HEALTH CARE"

Virgil A. McCleary†
Warsaw, Indiana

The educator, Hutchinson, makes some unique assumptions in the article "A Plea For a Program of Prepaid Health Care," May issue, AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.

In the first place, our free school system has proven very successful only because it was organized and, is still in the main, operated and financed on a local level. In conjunction with this statement, the writer will predict that with the federal government entering the school financial program, there will eventually be a deterioration of this system, provided that the federal government is allowed a strong influence in making policy for that school system.

Hutchinson states that there are people in these United States without proper health care. The veracity of this statement is granted. By the same token, let's look at the food situation in these United States. In Indiana, for illustration, there is township aid, help from the Federal-County Welfare Board, and charitable funds available for those not fortunate enough to have ample funds for groceries. In spite of all these organizations, there are *adults* as well as children without sufficient food in the writer's home town of 8,200 inhabitants and this is not a

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*Submitted on May 27, 1949, for publication in the July, 1949, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.

†Optometrist. Fellow, American Academy of Optometry.

predicament unusual to any other part of the United States. This being true, what is missing in this picture and how will a federal health bill solve the health problem any better than the food situation has been solved?

The statement is also made that there is deep seated dissatisfaction with the present setup and an insistent demand for a better system. It seems to the writer, that there are only a few socialized planners in which this is so terrifically deep seated. If the present system is so disliked, then why is so much respect and esteem given the family physician? Is it because he is a criminal at large, allowed to practice his dastardly deeds of ill repute, or is it because people realize that he represents a well educated profession doing a job well performed?

For those who have not as yet had the opportunity to read certain facts concerning socialized medicine, let me review a report made by Greer Williams in the March, 1949 issue of NATION'S BUSINESS.

It is interesting to note in the Williams report that we need not look to England for examples of a socialized health program. We have at San Francisco a good example of socialized inefficiency. Since 1937, some 12,000 people have been receiving benefit from a municipal employees' health service system. After 12 years, during which many changes were made in operating costs, policies of operation, and an increase of 5,000 membership, the system has failed and is now involved in a court fight over how it shall operate.

Williams also cites the case of the Michigan Medical Service which has had 1,300,000 subscribers for several or more years. J. C. Ketchum, executive director of the Michigan Medical Service, says it is impossible for either voluntary or compulsory insurance to offer comprehensive medical care at low cost and *still remain solvent*. Ketchum recently computed the cost of full medical care and Blue Cross hospitalization to be about $228.00. Ewing proposes to do this for $160.00 a year and adds dental, home nursing care, drugs, and appliances besides. The deficit could be drawn says Ewing, from general taxation.

Williams, in his article, also points out that physicians who can by ethics of their profession get the best health care, have as a group, the highest heart death rate in the United States. Heart disease is No. 1 on the list of deaths caused by disease.

Then there are the cases of cancer, brain hemorrhage, and death by accidental injury which Williams irrefutably points out cannot be solved better by any means than those now at hand.

Ewing, the proposer of the administration's compulsory health insurance bill, claims as a nation that we are losing 4,300,000 man days

of work each year due to bad health. Dr. Gilson Colby Engel, President of the Pennsylvania State Medical Society claims, "The majority of these work days lost are due to the common cold." Williams again points out that the best procedure recommended by physicians to alleviate a condition of the common cold is to stay at home in bed.

Hutchinson claims that the Ewing proposal is not a scheme for socialization since it is a workable prepayment plan. What is this workable prepayment plan mentioned? Does the author infer that the doctors will be prepaid?—obviously not. Then he must be inferring that the prepayment is made by the people to the government, who in turn pays the doctor for his services. However, this payment to the doctor cannot be made without organizing additional federal, state and local bureaus. In the writer's judgment this is socialism according to the Marx theory.

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CURRENT COMMENTS

Virginia Huck
Editorial Assistant

Optometrists will confer a favor by sending news items of general interest for this department, such as relate to new instruments, clinical techniques, education, visual health and optometric legislation and organization.

THE CASSVILLE & EXETER

A former president of the Academy has a new presidency to worry about. Dr. Arthur P. Wheelock of Des Moines, Iowa, has recently become president of the shortest standard gauge railroad in the United States. The Cassville & Exeter boasts 4.8 miles of track, one engine and one station. But the road is an important one as it links Cassville, Missouri, with the Frisco lines at Exeter, Missouri.

As associates and friends of Dr. Wheelock know, he has always been a railroad fan. He is a member of the Des Moines Railfans club, a group whose members take train trips for the fun of it and dream about a chance to run a locomotive.

At the moment, Dr. Wheelock is vacationing from his office and taking a work-out with his new hobby.

BRITISH HEALTH SCHEME HAS PUBLIC RELATIONS PROBLEMS

Public relations problems apparently are mounting for British optometrists. It seems there are those who believe some Britishers are

exploiting their prepared insurance by getting spectacles they really do not need. Not so, says the Association of Optical Practitioners in a press release to the profession entitled, "Are Your Spectacles Really Necessary?"

The press statement points out there is no evidence to support these charges:—

"The great demand for spectacles is a measure of the need and does not indicate any abuse of the scheme. We know from investigations carried out in this country and in the United States that about 40 per cent of the population need visual help, and this percentage increases as the population gets older, as is happening in Great Britain."

The statement goes on to explain who really needs spectacles, cites statistical data on the number of nearsighted, aged, and industrial workers who need glasses in Great Britain. It further states that the ophthalmic section of the Health Service is successful, apart from the hardships caused by delays in obtaining spectacles, due to inadequate production of lenses.

SHADES OF DR. BATES!

University of Minnesota students are seeing spots in front of their eyes these days—real ones—round, red and blue ones. Through the efforts of U. of M. consultant designer, Mr. J. Hopkins, classrooms in several buildings have two large, round spots, one red and one blue, painted on the front wall. Hopkins says the spots will give more rest to the eyes of both nearsighted and farsighted students. His theory is that blue is more relaxing to nearsighted people, while red is more restful for the farsighted ones.

"As for those having 20-20 vision, the spots are harmless," says Hopkins. "They're just there to relax the eyes."

Hopkins claims the student's eyes will be drawn automatically towards whichever color is more restful to him.

The theory has the backing of a University eye specialist—Dr. Robert R. Tracht, assistant professor of ophthalmology, who has spent the last few years studying eye relaxation qualities of various colors. Tracht claims that experiments prove that red has a marked relaxing effect on farsighted people and blue has a similar effect on nearsighted ones. His experiments included hanging of the American flag in St. Paul, Minnesota, classrooms for relaxation purposes.

Hopkins believes his University experiment is the first one of its kind, but doesn't think he has hit on the right shape yet for the spots.

Wouldn't it be more practical to work on a color scheme to keep students awake?

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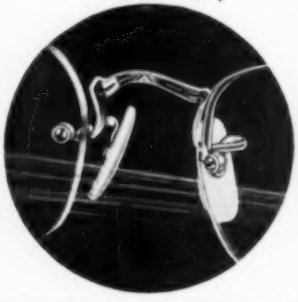

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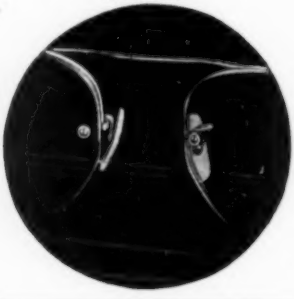

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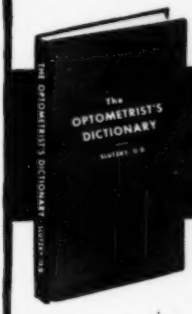

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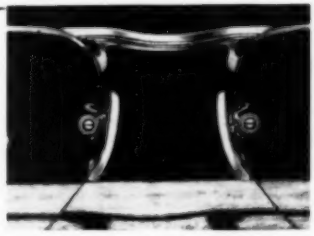

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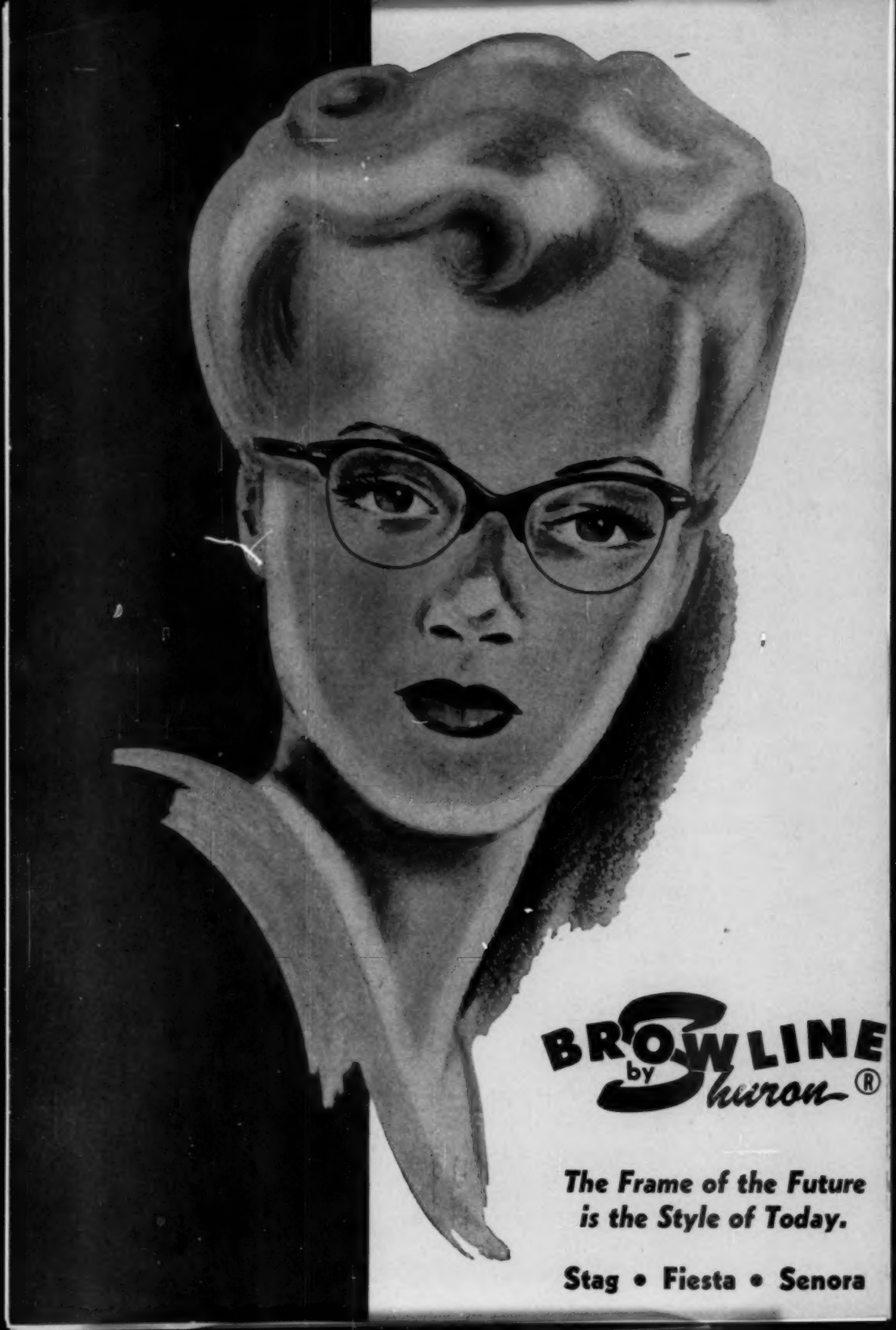
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